AMENDMENTS TO THE SPECIFICATION

Please replace the paragraph at pages 1 and 2: page 1, lines 23-28; page 2, lines 1-7 with the following paragraph:

Addressable visual displays typically have multiple display units such as pixels or subpixels. A separate auxiliary optical element is sometimes used in connection with each display to enhance or create certain visual ~~effect~~ effects. U.S. Patent No. 5,777,782 to Sheridon, for example, discloses a gyricon or rotating-particle display having an auxiliary optical structure which is a pre-formed array of lenses indexed to gyricon particles. Although the Sheridon patent relates to gyricon displays only, in principle the use of an auxiliary optical structure is not limited to the gyricon displays. A properly designed auxiliary optical structure may be used to enhance or create certain visual effects in other types of visual displays containing multiple display units, such as displays using the electronic inkbnased on the electrophoretic principle made by E. Ink Corp. For purposes of illustration, however, the present application uses structures of gyricon displays to demonstrate the concepts and the benefits of the inventive structure.

Please replace the paragraph at page 4: lines 1-12 with the following paragraph:

When the electric field is applied to the sheet, the adhesion of each particle to the cavity is overcome and the particles are rotated to point either their black or while hemispheres towards the transparent surface. Even after the electric field is removed, the structures (particles in specific orientations) will stay in position and thus create a bistable display until the particles are dislodged by another electric field. An image is formed by the pattern collectively created by each individual black and while hemisphere. Thus, by the application of an electric field addressable in two dimensions (as by matrix addressing scheme), the black and while sides of the particles can be caused to appear as the image elements (e.g. pixels or subpixels) of a displayed image. These bistable displays are particularly useful for remotely addressable displays that requires little power to switch and no power to maintain <u>the</u> display image for a long perod of time (e.g., months).

Please replace the paragraph at page 4, lines 13-24 with the following paragraph:

Gyricon display technology is described further in U.S. Patent No. 4,126,854 (Sheridon, "Twisting Ball Panel Display") and U.S. Patent No. 5,389,945 (Sheridon, "writing System Including Paper-Like Digitally Addressed Media and Addressing Device Therefor"). Further advances in black and white gyricon displays have been described in U.S. Patent No. 6,055,901 (Sheridon, "Twisting-Cylinder Display"). The above-identified patents are all hereby incorporated by reference. The Sheridon patents ~~disclosed~~ <u>disclose</u> a gyricon display which uses substantially cylindrical bichromal particles rotatably disposed in a substrate. The twisting cylinder display has ceratin advantages over the rotating ball gyricon because the elements can achieve a much higher packing density. The higher packing density leads to improvements in the brightness of the twisting cylinder display as compared to the rotating ball gyricon.

Please replace the paragraph at pages 4 and 5: page 4, lines 25-28; page 5-9, lines 1-7 with the following paragraph:

Gyricon displays are not limited to black and while images, as gyricon and other display mediums are known in the art to have incorporated color. Gyricon <u>displays</u> incorporating color have been described in U.S. Patent No. 5,760,761 titled "Highlight Color Twisting Ball Display", U.S. Patent No. 5,751,268 titled "Pseudo-Four Color Twisting Ball Display", U.S. Patent Application Serial No. 08/572,820 titled "Additive Color Transmissive Twisting Ball Display", U.S. Patent Application Serial No. 08/572,780 titled "Subtractive Color Twisting Ball Display", U.S. Patent No. 5,737,115 titled "Additive Color Tristate Light Valve Twisting Ball Display", U.S. Patent No. 6,128,124 titled "Additive Color Electric Paper Without Registration or Alignment of Individual Elements"<u>,</u> and European Patent No. EPO902410 titled "Methods for Making Spinnable Ball, Display Medium and Display Device". The above-identified patents are all hereby incorporated by reference.

Please replace the paragraph at pages 6 and 7: page 6, lines 22-28; page 7, lines 1-4 with the following paragraph:

To achieve higher packing density, the above method was modified in U.S. Patent No. 4,438, 160 to Ishikawa et al., which patent is hereby incorporated by reference ~~preference~~. In the Ishikawa patent, instead of using the swelling method to create cavities larger than the particles, the particles are coated with a layer of wax before being placed in the elastomer. The wax is later melted away, resulting in cavities that are larger than the particles. Presumably, because it is easier to control the thickness of the wax layer coated on the particles than to control the degree of swelling of the elastomer, it is also easier to achieve a higher density of particles by using the Ishilawa method. The actual improvement, however, is not significant enough to solve the problem. See U.S. Patent No. 5,825,529 to Crowley, which patent is hereby incorporated by reference.

Please replace the paragraph at page 7, lines 5-19 with the following paragraph:

To achieve still higher packing density, a gyricon display can be constructed without elastomer and without cavities. U.S. Patent No. 5,825,529 to Crowley, for example, uses no elastomer substrate. In the display in the Crowley patent, the bichromal particles are placed directly in the dielectric fluid. The particles and the dielectric fluid are then sandwiched between the two retaining members (e.g., between the addressing electrodes). There is elastomer substrate. Electrodes serve both to address particles and to retain particles and fluid in place. Particles and fluid can be sealed in the display by seals at either end of the display. In addition, the spacing between the electrodes is set to be as close to the diameter of the particle as is possible consistent with proper particle rotation, resulting in a monolayer display. The Crowley patent achieved a display with a closely packed monolayer having a light reflectance that surpasses that of the multi-layer displays in the prior art. The display in Crowley, however, achieves a higher packing density by sacrificing structural integrity. The Crowley display lacks internal support and has insufficient sealing. Particularly, the display will not work when placed vertically.

Please replace the paragraph at pages 7 and 8: page 7, lines 20-28; page 8, lines 1-11 with the following paragraph:

More fundamentally, even with the above improved methods of making twisting particle displays, the particles cannot be paced together to completely fill the are of the display because of the existence of interstices. Furthermore, regardless of which microstructure is used, and regardless of how the particles are packed, the particles often do not exactly rotate to the precise orientation to have only the side with the desired optical characteristics facing the viewer. Both partial filling and partial rotating contribute to decreased image contrast in the following manner: ~~Gyricon~~ gyricon displays use optically anisotropic particles that are selectively rotatable to communicate visual information. For example, in a display using bichromal spherical balls where each ball defines a display unit which conveys the characteristic color information of the spherical ball's hemisphere which is selectively turned to face the viewer, the unit display area is typically the projection area or image size of the ball. Due to the unfilled spaces between the particles and also due to the imperfect rotation which may show a wrong color or portions of contrasting (hence canceling) colors, each particle is surrounded by a peripheral area which does not carry any color information of the particle selectively rotated. Instead the peripheral area substantially reflects the optical characteristic of the substrate whish is typically dark. This phenomenon causes decreased contrast. The same phenomenon exists is displays where each unit display is defined by multiple particles.

Please replace the paragraph at page 8, lines 12-19 with the following paragraph:

The auxiliary optical structure in U.S. Patent No. 5,777,782 to Sheridon is not used to solve the above-identified low contrast problem. Rather, it is used to focus a visual element of gyricon particles to form a projected image on the other side of the transmissive gyricon display. Furthermore, the auxiliary optical structre in that patent is a pre-formed array of fly's-eye lenses which need to be then precisely aligned in each of the x, y, and z directions with the gyricon particles. Such requirement of alignment or indexation between a pre-formed array of lenses and a separately formed gyricon display structure is difficult and costly.

Please replace the paragraph at page 10, lines 11-28 with the following paragraph:

The invention will now be described with reference to the drawings. For convenience, the drawing ~~figures~~ depict a reflective gyricon display with each optical element being associated with one spheroidal gyricon particle. The inventive structure in accordance with the present invention, however, may also be used to enhance or create certain optical effects in other types of microstructures. Generally, any microstructure that contains an element having a certain optical aspect by modulating or interacting with an incident electromagnetic wave and giving rise to an identifiable optical effect may use the assistint optical element of the present invention to improve or enhance the optical effect. For example, where elements having optical aspects pertaining to electromagnetic waves other than a visible light are used, the inventive microstructure may be used as a device for optical purposes other than visual displays. Examples for such applications include, but are not limited to, visual displays using microstructures containing a display element. A display element can be anything that carries certain visual information.

Please replace the paragraph at page 11, lines 1-5 with the following paragraph:

Particularly, the element having an optical aspect may be optically anisotropic (i.e., having two or more optical aspects) and capable of switching among the optical aspects in response to an external signal. The twisting particles or rotating balls used in gyricon displays are examples of such responsive elements having an optical anisotropy.

Please replace the paragraph at page 11, lines 6-10 with the following paragraph:

Visual displays that may use the inventive lens structure typically contain multiple display units, each display unit including one or more responsive elements as display elements. Besides gyricon displays, examples of such visual displays include, but are not [[be]] limited to, displays based on the electrophoretic principle such as electronic ink by E Ink Corp.

Please replace the paragraph at page 12, lines 3-7 with the following paragraph:

With reference to FIG. 1A, a gyricon display **2** comprises a plurality of repetitive display units **4**. each display unit **4** comprises a gyricon particle **6** (a spherical ball as shown), an optical lens [[**38**]] **8**, and a portion of substrate **9**. Each particle 6 has two optically distinct ~~sides~~ hemispheres **6a**, **6b**, one facing the viewer (now shown) positioned above and the other facing away from the viewer.

Please replace the paragraph at page 12, lines 8-20 with the following paragraph:

With reference to FIG. 1B, a viewer from above (now shown) sees [[an]] a top image of each display unit 4 (shown in FIG. 1A). when an optically anisotropic particle 6 is selectively rotated, the [[side]] hemisphere facing the viewer has a dominant color. This is often true even if the rotation is imperfect to a certain extent. Without assistance of the optical lens [[**38**]] **8** (shown in FIG. 1A), each display unit **6** has an effective display area **A** which is typically the projection area or image size of the ball. Due to the unfilled spaces between the particles **6** is surrounded by a peripheral area **B**. Without assistance of an assisting optical element, the peripheral area **B** does not carry any color information of the particle selectively rotated, instead it reflects the optical characteristic of the substrate which is typically dark. Where the peripheral area **B** is substantial as compared to display area **A**, contrast of the display decreases. In addition, incomplete or over rotation also lowers contrast by contributing to area **B** due to showing portions of contrasting colors instead of a single dominant color.

Please replace the paragraph at page 12, lines 21-27 with the following paragraph:

The optical lens [[**38**]] **8** helps to enhance the contrast. With the optical lens [[**38**]] **8**, the dominant color of the particle [[side]] hemisphere facing the viewer **6a** is spread or diffused into the peripheral area through refraction. As a result, when viewed through the assisting optical element, the viewer sees an image of the display unit **4** larger than the actual size of the particle. The enlarged image has the same dominant color as that of top [[side]]

hemisphere **6a** of the corresponding particle and diminishes the image-derogating effect caused by the peripheral area **B**.

Please replace the paragraph at page 13, lines 4-5 with the following paragraph:

~~Description~~ A description of preferred embodiments according to the spirit of the invention follows.

Please replace the paragraph at page 13, lines 7-11 with the following paragraph:

With reference to FIG. 2, a single display unit **4** in an embodiment according to the present invention includes a converging lens **38** disposed at the top perimeter edge **37** of [[the]] a cavity **33**. The converging lens **38** forms an enlarged image of the upper portion (white hemisphere 6a as shown) of the [[ball]] particle **6** as explained below.

Please replace the paragraph at page 13, lines 12-21 with the following paragraph:

When placed properly in relation to an object, a converging lens may form an enlarged image of the object. When the object is placed within the focus length of the converging lens, for example, the viewer from the other side of the lens will see an enlarged image of the object formed on the same side as the object relative to the lens. With reference to FIG. 2, light **35** from a top portion **14** of particle 6 is refracted through the converging lens **38** before it reaches the viewer from above (not shown). If, for example, the top hemisphere **6a** of the [[ball]] particle **6** is located within the focal length of the converging lens **38**, an enlarged image of the top hemisphere **6a** will be formed on the same side as the [[ball]] particle **6** (i.e., the opposite side to the viewing side) relative to the lens to the viewer from above.

Please replace the paragraph at page 13, lines 22-26 with the following paragraph:

If the enlargement is sufficient to cover a substantial amount of the peripheral

area around the [[ball]] particle **6**, the contrast of the display will be enhanced. The amount of enlargement, however, should not be excessive. An over-enlarged image starts to blur with the images of adjacent [[balls]] particles **6** and will lead to decreased resolution of display.

Please replace the paragraph at page 14, lines 1-6 with the following paragraph:

The degree of enlargement is determined by the focal length of the converging lens **38** and the distance between the top hemisphere **6a** and the lens **38**. The maximum amount of enlargement without blurring the display is determined by the size of the peripheral area around each [[ball]] particle **6**. to optimize the display **4**, it is therefore important to be able to control the focal length of the lenses **38** and the sizes of the cavities [[**3**]] **33** in the process of manufacturing the display **4**.

Please replace the paragraph at page 14, lines 7-11 with the following paragraph:

In FIG. 2, the converging lens **38** is spaced from the rotating [[ball]] particle **6** and the space therebetween is filled with entrapped air (now shown). Alternatively, a transparent filler material **12** may be used. Besides being an optional support for the lens **38**, the filler material **12**, when properly selected and applied, helps to create bistability of the gyricon particles **6**.

Please replace the paragraph at page 14, lines 22-27 with the following paragraph:

FIG. 2 ~~and FIG. 3 both illustrate~~ illustrates a single display unit **4**. the actual visual display comprises a two-dimensional array of such single display units. FIG. 1A, for example, illustrates a partial sectional view of a monolayer black and white gyricon display according to the present invention where the gyricon display **2** comprises a plurality of display units **4**. Each display unit **4** has an optical lens [[**38**]] **8** on top of a particle **6**.

Please replace the paragraph at page 15, lines 1-17 with the following paragraph:

To make a display in accordance with the present invention, a substrate [[9]] containing cavities that have surfaced openings must first be made. The display in the Crowley patent does not have a substrate [[9]] containing cavities and is therefore not suitable for implementing the improvement according to the present invention. In addition, the display in the Crowley patent has two other potential problems. First, the display package is environmentally and mechanically sealed only around the perimeter of the display. This results in the package being susceptible to cracking as may result from wear and tear; in this instance, a single crack would be adequate to enable all of the dielectric oil to drain or evaporate away, thereby disabling the function of the display. Additionally, the package is susceptible to buckling, and the elastomer-particle film can sag or slide out of position because of gravity (especially when held vertically for long periods of time, such as for display signs). This is because the mechanical support for the package is primarily the thin polymer films on the front and back sides, and because the reinforcement of these films occurs only where they are bonded together along the periphery.

Please replace the paragraph at page 16, lines 3-8 with the following paragraph:

An exemplary preferred method of making a pre-formed substrate [[9]] containing cavities [[33]] is described in ~~details~~ detail in the commonly-owned and concurrently filed U.S. patent application titled "Post and Pocket Microstructures for Movable Particles Having an Optical Effect" ~~and filed concurrently~~ (Attorney Docket Number M507.12-14). The disclosure of the above-identified patent application is hereby incorporated ~~herein~~ by reference.

Please replace the paragraph at page 16, lines 9-20 with the following paragraph:

The concepts and the methods of manufacture disclosed in that application may be used to pre-form a substrate [[9]] containing cavities [[33]] that have proper geometric shapes and pattern to accommodate both optically anisotropic particles [[6]] such as gyricon particles and assisting optical lens [[38]]. As described in that application, the post and pocket microstructures have many other advantages. Particularly, the pocket and post structure has a

surface structure such as the cavities which are open from the top during manufacturing. Such a structure accommodates the process of adding or directly forming an optical lens [[38]] on the substrate. Additionally, where a dielectric fluid is used, such as in a gyricon display using rotatable particles, the dielectric fluid does not need to diffuse through an elastomer. This allows a much greater variety of dielectric fluids to be used that in the case [[for]] of the swollen elastomer sheets.

Please replace the paragraph at pages 16 and 17: page 16, lines 21-27; page 17, lines 1-9, with the following paragraph:

With ~~an above~~ a preferred pre-formed substrate [[9,]] as discussed above, an assisting optical lens [[38]] may be included in the following two different ways: 1) pre-forming the assisting optical lens [[38] separately (e.g., formed on a top plate that also has the addressing electrodes) and then placing then over the substrate [[9]], [[and]] or 2) forming the assisting optical lens [[38]] directly or integrally on the elastomer substrate [[9]]. As used in the present application, a process of "directly forming in assisting optical element on the substrate" means a process that involves more than simple placement of a pre-formed assisting optical element on the substrate or making necessary physical connections between an assisting optical element and the substrate. However, directly forming the lenses [[38]] on the substrate [[9]] is preferred for the following reasons: 1) when the pre-formed substrate disclosed in the above identified patent application is used, fabrication of the substrate and fabrication of the assisting optical element (e.g. lens **38**) may be made during one single integrated manufacturing process to improve efficiency and lower the cost; and 2) an integrated manufacturing process additionally provides an intrinsic solution to the difficult problem of exact indexing or registration between each lens [[38]] and its corresponding display unit [[4]].

Please replace the paragraph at page 17, lines 10-21 with the following paragraph:

Assisting optical elements other than lenses [[38]] may also be used to ~~enhanced~~ enhance the ~~contract~~ contrast of a display. For example, as described in ~~details~~

detail in the commonly-owned and concurrently filed U.S. patent application titled "Microstructures with Assisting Optical Elements to Enhance an Optical Effect" ~~and filed concurrently~~ (Attorney Docket Number M507.12-14), a reflective corona shouldering a particle[[,]] creates an appearance [[of]] that the surface of the particle is larger than the actual size of the surface through reflection of [[the]] light from the surface, given that the reflective corona is larger than the particle. A reflective corona may simply be made of metalized reflective surfaces, or alternatively formed by using the principle of total internal reflection in which a total reflection is created at an interface of two different materials at certain incident angles of [[the]] light, even though the interface is not made of a material which is highly reflective in the ordinary sense.

Please replace the paragraph at pages 17 and 18: page 17, lines 22-28; page 18, lines 1-2 with the following paragraph:

The optical lens structure in accordance with the present invention offers an alternative to the above assisting optical elements. Besides being optically distinctive, the optical lens structure also offers an alternative way of fabricating assisting optical elements on a display. For example, because the lenses [[**38**]] are formed subsequent to the placement of the display ~~elements~~ particles [[**6**]] (such as gyricon particles **6**) into the substrate, the lenses [[**38**]] may be formed directly on top of the display particles [[**6**]], resulting in a lens structure automatically conforming to the geometric shape of the particles, a benefit in addition to the above-discussed automatic indexing.

Please replace the paragraph at page 18, lines 3-6 with the following paragraph:

Converging lenses [[**38**]] can be made by conventional methods, such as compression molding. Conventional methods, if used to pre-form the lenses separately, will be less preferable due to the difficulties [[to]] of ~~register~~ registering each lens [[**38**]] with a corresponding cavity [[**33**]].

Please replace the paragraph at pages 18 and 19: page 18, lines 20-27; page 19, lines 1-7 with the following paragraph:

FIG. 3 and FIG 4 illustrate how a two-dimensional array of micro-lenses **38** is formed from the lens-forming layer **46**. In FIG. 3, the plate assembly **42** is placed over a two-dimensional array of display units **4**. Heat and pressure are then applied to the plate assembly **42** as shown in FIG. 4. While the high temperature backing plate **44** and the high temperature membrane **48** can withstand the high temperature, essentially all of the lower melt temperature lens-forming material **46** is melted. The pressure deforms the membrane **48** (but does not substantially deform the backing plate **44** as the plate **44** is rigid) and pushes the membrane **48** into the cavities **33**. Since the membrane **48** is withheld at top perimeter edges **37** of the cavities **33** but pushed into each cavity **33** in the middle, the membrane **48** is contoured into a spherical surface (lens **38**) in each cavity **33**. At the same time, the [[melt]] lens-forming material **46** flows in response to both gravity and the pressure exerted by the ~~topplate~~ backing plate **44**. The flow of [[melt]] lens-forming material **46**, however, is constrained at the bottom by the contoured and strained membrane **48** due to surface tension. The final result is a steady equilibrium state of pressure, forming a spherical lens **38**.

Please replace the paragraph at page 19, lines 8-13 with the following paragraph:

Only [[a]] minimum pressure and temperature is preferred. As the pressure increases, all lens-forming material **46** flows into the cavities **33** and the backing plate **44** will eventually come in contact with the top perimeter edge **37** of the cavities. This condition will prevent further flow of the lens-forming material **46**. As a result, further pressure only results in ~~strain on~~ straining the structure and contributes nothing [[in]] to the lens making.

Please replace the paragraph at page 19, lines 14-19 with the following paragraph:

The temperature should be higher than the melting temperature of the lens-forming material **46** but less than the melting temperature of the ~~topplate~~ back plate **44**, the membrane **48**, and the substrate [[4]] 9 (shown in FIG. 1A). A temperature higher than the minimum melting temperature of the lens-forming material **46** will only result in a faster process of equilibrium to a limited degree, and is usually unnecessary or even harmful because

too high a temperature may lead to difficulties in operation.

Please replace the paragraph at pages 19 and 20: page 19, lines 20-27; page 20, lines 1-3 with the following paragraph:

In the above process, the focal length of the lenses **38** is found by the equation $F = (H^2 + A^2)/2H$, where H is the thickness of the lens **38** at the center as shown in FIG. 4, while A is the diameter of the top perimeter ~~openings~~ edge **37** (full view not shown) of the cavity **33**. H itself is determined by the total volume V of each lens [[V]] according to the equation $V = 1/6\pi H(3A^2 + H^2)$. That is, for a given V and A, the value of H can be readily determined by solving the above equation. If the lens-forming ~~layer~~ material **46** has a uniform thickness T, each unit cell of the array will have a precise volume V of lens-forming material 46 associated with it. For example, if the top opening of each cavity 33 has an area of A^2 (full view not shown), each unit cell will have the volume $V = TA^2$ of lens-forming material **46** associated with it. Therefore, focal length F of the lenses **38** is ultimately determined by T and A and hence easily controlled.

Please replace the paragraph at page 20, lines 11-15 with the following paragraph:

Once the lens array [[**38**]] is formed, the backing plate **44** may be separated from the array of cavities [[**4**]] **33** or may remain adhered. The lens array may also be separated [[form]] from the array of cavities [[**4**]] **33** and used for other purposes. In the present invention, however, the lens array [[**38**]] and the array of cavities [[**4**]] **33** are kept together, resulting in intrinsic registration.